REMARKS

In the Office action mailed November 6, 2002, claims 1 – 10, 12-14, 17, 19, 21-30, 32-39, 41-45, 47-51, 53-60 and 62-71 were rejected and claims 11, 20, 31, 40, 46, 52, 61, and 72 were objected to. In response, applicants have canceled claims 5, 17, 25, 50, 51 and 66, amended claims 1, 12, 21, 41, and 62 and added new claims 73 - 119 and hereby request further examination and reconsideration of the application in view of the amended and added claims and the below-provided remarks.

I. Allowable Subject Matter

Claims 11, 20, 31, 40, 46, 52, 61, and 72

The Office action states that claims 11, 20, 31, 40, 46, 52, 61, and 72 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. (Office action, page 9, item 3). Applicants have added new claims 73, 80, 90, 98, 102, 105, and 113, each of which has been written to include all of the limitations of the respective base claims and any respective intervening claims as suggested in the Office action. Following each new independent claim are those dependent claims that previously depended from the earlier independent claims 1, 12, 21, 32, 41, 47, 53, and 62, respectively. A brief description of these new claims is provided below.

New claims 73 - 79

New claim 73 is formed by combining the limitations of claims 1, 9, 10, and 11.

Claim 11 is objected to as being dependent upon a rejected base claim; but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 11, as filed, depends from claim 10, which depends from claim 9, which depends from claim 1. Applicants have added new claim 73, which is formed by adding the limitations of independent claim 1 and the limitations

of dependent claims 9, 10, and 11. Applicants assert that new claim 73 is in an allowable condition.

New claims 74 - 79 depend from new claim 73 and are similar to claims 2 – 4 and 6 - 8 as filed. Applicants assert that new claims 73 - 79 are allowable based on an allowable new claim 73.

New claims 80 - 82

New claim 80 is formed by combining the limitations of claims 12, 19, and 20.

Claim 20 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 20, as filed, depends from claim 19, which depends from claim 12. Applicants have added new claim 80, which is formed by adding the limitations of independent claim 12 and the limitations of dependent claims 19 and 20. Applicants assert that new claim 80 is in an allowable condition.

New claims 81 and 82 depend from new claim 80 and are similar to claims 13 and 14 as filed. Applicants assert that new claims 80 - 82 are allowable based on an allowable new claim 80.

New claims 83 - 89

New claim 83 is formed by combining the limitations of claims 21, 29, 30, and 31.

Claim 31 was objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 31, as filed, depends from claim 30, which depends from claim 29, which depends from claim 21. Applicants have added new claim 83, which is formed by adding the limitations of independent claim 21 and the limitations of dependent claims 29, 30, and 31. Applicants assert that new claim 83 is in an allowable condition.

New claims 84 - 89 depend from new claim 83 and are similar to claims 22 – 24 and 26 - 28 as filed. Applicants assert that new claims 83 - 89 are allowable based on an allowable new claim 83.

New claims 90 - 97

New claim 90 is formed by combining the limitations of claims 32 and 40.

Claim 40 was objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 40, as filed, depends from claim 32. Applicants have added new claim 90, which is formed by adding the limitations of independent claim 32 and the limitations of dependent claim 40. Applicants assert that new claim 90 is in an allowable condition.

New claims 91 - 97 depend from new claim 90 and are similar to claims 33 – 39 as filed. Applicants assert that new claims 90 - 97 are allowable based on an allowable new claim 90.

New claims 98 - 101

New claim 98 is formed by combining the limitations of claims 41, 45 and 46.

Claim 46 was objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 46, as filed, depends from claim 45, which depends from claim 41. Applicants have added new claim 98, which is formed by adding the limitations of independent claim 41 and the limitations of dependent claims 45 and 46. Applicants assert that new claim 98 is in an allowable condition.

New claims 99 - 101 depend from new claim 98 and are similar to claims 42- 44 as filed. Applicants assert that new claims 98 - 101 are allowable based on an allowable new claim 98.

New claims 102 - 104

New claim 102 is formed by combining the limitations of claims 47 and 52.

Claim 52 was objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 52, as filed, depends from claim 47. Applicants have added new claim 102, which is formed by adding the limitations of

independent claim 47 and the limitations of dependent claim 52. Applicants assert that new claim 102 is in an allowable condition.

New claims 103 and 104 depend from new claim 102 and are similar to claims 48 and 49 as filed. Applicants assert that new claims 102 and 104 are allowable based on an allowable new claim 102.

New claims 105 - 112

New claim 105 is formed by combining the limitations of claims 53 and 61.

Claim 61 was objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 61, as filed, depends from claim 53. Applicants have added new claim 105, which is formed by adding the limitations of independent claim 53. Applicants assert that new claim 105 is in an allowable condition.

New claims 106 - 112 depend from new claim 105 and are similar to claims 54 - 60 as filed. Applicants assert that new claims 105 - 112 are allowable based on an allowable new claim 105.

New claims 113 - 119

New claim 113 is formed by combining the limitations of claims 62, 70, 71, and 72.

Claim 72 was objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 72, as filed, depends from claim 71, which depends from claim 70, which depends from claim 62. Applicants have added new claim 113, which is formed by adding the limitations of independent claim 62 and the limitations of dependent claims 70, 71, and 72. Applicants assert that new claim 113 is in an allowable condition.

New claims 114 - 119 depend from new claim 113 and are similar to claims 63 – 65 and 67 - 69 as filed. Applicants assert that new claims 113 - 119 are allowable based on an allowable new claim 113.

II. Claim Rejections Under 35 U.S.C. 102

Claims 1, 12, 17, 21, 41, 44, and 62

Claims 1, 12, 17, 21, 41, 44, and 62 were rejected as being unpatentable over Graves, U.S. Patent Number 6,215,789 B1 (hereinafter Graves). However, Graves was published March 6, 2001 whereas Applicants filed November 17, 2000 and therefore filed before Graves was published for Claim rejections under 35 U.S.C. 102(e).

Independent Claims 1, 12, 21, 41, and 62

Claims 1, 12, 21, 41, and 62 were rejected as being unpatentable in view of Graves. Claims 1, 12, 21, 41, and 62 have been amended to state that the upstream packets are formatted according to IEEE 802.3, which is patentably distinct from Graves' use of fixed size, synchronous ATM cells. Support for the amendment is found in dependent claims 5, 13, 25, 36, 57, and 66 and in the specification at page 5, lines 5 – 6 and page 6, lines 8 - 10.

2.1 Independent Claims 1, 12, and 21

Claims 1, 12, and 21 were rejected as being unpatentable in view of Graves. Applicants assert that claims 1, 12, and 21 are patentable over Graves because Graves does not disclose the downstream transmission of asynchronous variable-length packets or the upstream transmission of asynchronous multiple variable-length packets in IEEE 802.3 format within ONU-specific time slots. Applicants' remarks will first address transmissions in the downstream direction followed by transmissions in the upstream direction.

Downstream Transmissions - Graves discloses a system and method in which downstream data is transmitted in synchronous, fixed-length ATM cells. With regard to downstream transmissions, Graves discloses "Scenario B [which entails] Frame Relay (or similar packetized) service carried across an ATM core network is delivered to and from an end user as a Frame Relay service" (Graves, col. 11, lines 37 – 40) wherein "ATM cells arriving from the core network and carrying the Frame Relay service are routed by

switch matrix to a first DSP. DSP is dedicated to the process of reassembling segments of Frame Relay packets contained within the ATM cell stream into pure Frame Relay packets." (Graves, col. 12, lines 57 – 62). Additionally, Scenario A of Graves is in the same format as Scenario B, as "the commonness of the data format communicated between the HDT and the ONUs (and vice versa) is an important property of the present invention." (Graves, col. 13, lines 26 – 28). That is, Graves only discloses a system and method in which downstream transmissions are made using fixed-length and payload ATM synchronous frames, similar to a passive optical network (APON).

In contrast, Applicants recite in claims 1, 12, and 21 that data is transmitted downstream in "variable-length downstream packets," as contrasted to the Graves' fixed-length and fixed-payload ATM synchronous frames. Transmitting data in variable-length downstream packets is depicted in Fig. 4 of Applicants' specification. In particular, Fig. 4 includes an expanded view of a variable-length packet (430) that is for downstream transmission. In sum, Graves only discloses transmitting data downstream in fixed-length ATM cells, while Applicants claim a system and method in which data is transmitted downstream in variable-length packets. Applicants therefore assert that claims 1, 12, and 21 are patentable over Graves. Graves teaches away from variable payloads with the use of ATM, and therefore, the Graves reference is relevant and persuasive evidence of the patentability of the claimed invention.

Upstream Transmissions – Graves discloses a system and method in which each ONU upstream transmissions is segmented into fixed-sized ATM cells, transported in synchronous frames, and then reassembled at the other end (Segmentation and Re-assembly (SAR)) at the HDT, as described above. Again, Graves discloses a system and method in which upstream transmissions are made using fixed-length and fixed-payload ATM synchronous cells. Specifically, Graves discloses that ATM format is integral in the payload of the Frame Relay data packet (Graves, col. 19, lines 40 –44) and that the ATM format is an important property of the invention taught in Graves (col. 13, lines 26 – 29).

In contrast, Applicants now recite in claims 1, 12, and 21 that the upstream packets are formatted according to IEEE 802.3. Graves teaches away from using IEEE

802.3 because the ATM data format, not IEEE 802.3 format, is an important property of the Graves invention *Id*. It is well settled that when prior art references teach away from the claimed invention, the references are relevant and persuasive evidence of the patentability of the claimed invention.

Graves only discloses ONU-specific time slots that are filled with fixed-length ATM cells, while Applicants claim a system and method in which data is transmitted upstream in ONU-specific time slots that are filled with multiple variable-length packets. Applicants assert, therefore, that claims 1, 12, and 21 are patentable over Graves.

2.2 Claim 17

Claim 17 is canceled and therefore is not addressed herein.

2.3 Claim 41

Claim 41 was rejected as being unpatentable in view of Graves. Applicants assert that claim 41 is patentable over Graves because Graves does not disclose the downstream transmission of asynchronous variable-length packets or the upstream transmission of asynchronous multiple variable-length packets in IEEE 802.3 format within ONU-specific time slots. Applicants' remarks will first address transmissions in the downstream direction followed by transmissions in the upstream direction.

Downstream Transmissions - Graves discloses a system and method in which downstream data within Frame Relay packets is transmitted in fixed-length ATM cells. With regard to downstream transmissions, Graves discloses "Scenario B [which entails] Frame Relay (or similar packetized) service carried across an ATM core network is delivered to and from an end user as a Frame Relay service" (Graves, col. 11, lines 37 – 40) wherein "ATM cells arriving from the core network and carrying the Frame Relay service are routed by switch matrix to a first DSP. DSP is dedicated to the process of reassembling segments of Frame Relay packets contained within the ATM cell stream into pure Frame Relay packets." (Graves, col. 12, lines 57 – 62). Additionally, Scenario A of Graves is in the same format as Scenario B, as "the commonness of the data format communicated between the HDT and the ONUs (and vice versa) is an important property

of the present invention." (Graves, col. 13, lines 26 – 28). That is, Graves only discloses a system and method in which downstream transmissions are made using fixed-length and fixed-payload ATM synchronous frames, as used in an APON.

In contrast, Applicants recite in claim 41 that data is transmitted downstream in "variable-length downstream packets." Transmitting data in variable-length downstream packets is depicted in Fig. 4 of Applicants' specification. In particular, Fig. 4 includes an expanded view of a variable-length packet (430) for downstream transmission. Graves only discloses transmitting data downstream in fixed-length ATM cells, while Applicants claim a system and method in which data is transmitted downstream in variable-length packets. Applicants therefore assert that claim 41 is patentable over Graves. Graves teaches away from variable payloads with the use of ATM, and therefore, the Graves reference is relevant and persuasive evidence of the patentability of the claimed invention.

Synchronization markers – Graves teaches of the use of the exclusive use of the inherently synchronous ATM format (Graves, col. 19, lines 40 –44, col. 13, lines 26 – 29). Time slot information (start/stop) is always carried in the header of the structure in the Graves ATM system. Applicants do not claim an integral header (as an ATM address) with timeslot information as a best mode or requirement for every packet. Applicants' system allows frames to be sent asynchronously, but uses an out-of-band sync marker to carry the clock reference to the ONU; these markers appear in between the IEEE 802.3 frames so that timeslot information is communicated as separate messages to provide the reference clock to the ONU. Conversely, Graves carries clock reference in the overhead address of each ATM cell.

In contrast, Applicants now recite in claim 41 that the upstream packets are formatted according to IEEE 802.3. Graves teaches away from using IEEE 802.3 because the ATM data format, not IEEE 802.3 format, is an important property of the Graves invention. Graves only discloses ONU-specific time slots that are filled with fixed-length ATM cells, while Applicants claim a system and method in which data is transmitted upstream in ONU-specific time slots that are filled with multiple variable-length IEEE 802.3 packets. Applicants assert, therefore, that claim 41 is patentable over Graves.

2.4 Claim 44

Claim 44 now recites that the variable-length packets are according to IEEE 802.3 format. Applicants assert claim 44 now is allowable based on the now allowable base claim 41.

2.5 Claim 62

Claim 62 was rejected as being unpatentable in view of Graves. Graves discloses a HDT and a plurality of ONUs connected by a passive optical network (PON) in which data flows upstream and downstream exclusively in synchronous ATM cells and synchronization frame and time intervals as an APON using time division multiplexing (Graves, col. 19, lines 40 –44, col. 13, lines 26 – 29). That is, Graves only discloses a system and method in which upstream and downstream transmissions are made using fixed-length and fixed-payload synchronous ATM cells, not multiple variable-length asynchronous packets. Graves only discloses ONU-specific time slots that are filled with fixed-length ATM cells.

In contrast, Applicants assert that claim 62 is patentable over Graves because Graves does not disclose the downstream transmission of asynchronous variable-length packets or the upstream transmission of asynchronous multiple variable-length packets in IEEE 802.3 format within ONU-specific time slots. Applicants do claim a system and method in which data is transmitted upstream in ONU-specific time slots that are filled with multiple variable-length IEEE 802.3 packets.

Further, Graves teaches of the use of the exclusive use of the inherently synchronous ATM format (Graves, col. 19, lines 40 –44, col. 13, lines 26 – 29). Time slot information (start/stop) is always carried in the header of the structure in the Graves ATM system. Applicants do not claim an integral header (as an ATM address) with timeslot information as a best mode or requirement for every packet. Applicants' system allows frames to be sent asynchronously, but uses an out-of-band sync marker to carry the clock reference to the ONU; these markers appear in between the IEEE 802.3 frames so that timeslot information is communicated as separate messages to provide the

reference clock to the ONU. Conversely, Graves carries clock reference in the overhead address of each ATM cell.

In contrast, Applicants now recite in claim 62 that the upstream packets are formatted according to IEEE 802.3. Graves teaches away from using IEEE 802.3 because the ATM data format, not IEEE 802.3 format, is an important property of the Graves invention. Graves only discloses ONU-specific time slots that are filled with fixed-length ATM cells, while Applicants claim a system and method in which data is transmitted upstream in ONU-specific time slots that are filled with multiple variable-length IEEE 802.3 packets. Applicants assert, therefore, that claim 62 is patentable over Graves.

of the present invention." (Graves, col. 13, lines 26 – 28). That is, Graves's system is specifically directed to an ATM cell based network environment, which includes the point-to-multipoint network, the broadband ATM network, and the servers.

The Graves' system teaches of Payloads within Frame Relay packets which are encapsulated into ATM cells through SAR and transported across a Frame structure, wherein the ATM cells are processed by SAR back into Frame Relay packets and payloads. In Graves, the variable sized Frame Relay packets are first broken up into fixed sized ATM cells which are then transported over a sync structure, therefore the SAR function is always needed for Graves. Further, the level of SAR in Graves represents required encapsulation of Frame Relay packets for ATM cell; the further from the transport state, the more costly SAR becomes. In Graves, frames are transported synchronously in ATM format, with the timeslot info (start/stop) always carried in the header of the structure, as necessitated by the ATM format. Each ATM cell carries reference time information in the address overhead.

In contrast, the format Applicants' use is native IEEE 802.3 that naturally accommodates an IP payload. Applicants' system and method teaches of IEEE 802.3 packets, using SAR in the upstream direction, and only if the packet size is larger than the allocated timeslot, not using SAR all of the time for every frame, as in Graves. Therefore, IEEE 802.3 packets are generally transported asynchronously and without encapsulation or further processing because the packets are in the native IEEE 802.3 format. Applicants' system allows frames to be sent asynchronously, but uses an out-of-band sync marker to carry the clock reference to the ONU; these markers appear in between the IEEE 802.3 frames while timeslot scheduling information is communicated as separate messages to the ONU.

The Graves fiber-in-the-loop communications passive optical network (PON) is connected to an ATM based network, the fiber-in-the-loop PON uses an ATM based Frame structure as the data link layer protocol between the OLTs and the ONUs. If Graves were to modify the disclosed system to utilize IEEE 802.3 formatted variable-length packets as the data link layer protocol between the OLT and the ONUs, the resulting fiber-in-the-loop PON would not be directly compatible with the ATM network. In particular, conversions between the IEEE 802.3 formatted variable-length packets and

the fixed length ATM cells would be required for all communications between the OLT and the ATM network. The conversions would require even more hardware and/or software, including beyond the required SAR encapsulation of every frame, that would add further cost to the system and that would add processing delay to the transmissions. Because modifying the fiber-in-the-loop PON disclosed by Graves to utilize IEEE 802.3 would result in a system that is not directly compatible with the networks to which the point-to-multipoint PON is connected, Applicants assert that Graves teaches away from modifying the system of Graves to utilize IEEE 802.3 formatted variable-length packets. It is well settled that when prior art references teach away from the claimed invention, the references are relevant and persuasive evidence of the patentability of the claimed invention.

In further support of the assertion that claims 2, 5, 13, 22, 25, 33, 36, 42, 48, 54, 63, and 66 are not rendered obvious in view of Graves, Applicants point out that at the time of the invention, there was an established and widely accepted standard for point-to-multipoint PONs that is based on the ATM protocol. The standard, known as the full service access network (FSAN) standard, specifies the use of fixed-length ATM cells between the OLTs and ONUs in a point-to-multipoint PON. Applicants assert that adapting the system of Graves to utilize the IEEE 802.3 protocol does not provide a clear economic advantage, as is suggested in the Office action (page 5, item 2.1) as a motivating factor for making the modification, because the system would not conform with the FSAN standard. That is, modifying the Graves system to utilize the IEEE 802.3 protocol would result in a system that does not conform to the widely accepted FSAN standard. Thus, modifying the Graves system does not provide a clear economic advantage. Applicants assert, therefore, that the position propounded in the Office action does not meet the threshold for a *prima facie* case of obviousness.

3.2 Claims 3-4, 6-7, 14, 23-24, 26-27, 34-35, 37-38, 43, 49, 55-56, 58-59, 64-65, and 67-68

Claims 3-4, 6-7, 14, 23-24, 26-27, 34-35, 37-38, 43, 49, 55-56, 58-59, 64-65, and 67-68 recite a system and method in which the variable-length packets include the lengths of an IP datagram plus packet overhead. Graves discloses a method and

apparatus for synchronous ATM cells which are segmented and transported upstream and downstream between a HDT and ONU and are designed to transport data such as POTS or ISDN. The Office action states, "Graves does not disclose that the lengths of the variable-length upstream and downstream packets include the lengths of an IP datagram plus packet overhead." The Office Action goes on to conclude that "[h]owever, IP packets are well-known in the telecommunication field" and "[i]t would have been obvious to one having ordinary skill in the art at the time the invention was made to adapt IP packets into the system disclosed by Graves for economic reasons since IP is a widely used protocol in Networks." (Office action page 5, item 2.2)

Applicants assert that claims 3-4, 6-7, 14, 23-24, 26-27, 34-35, 37-38, 43, 49, 55-56, 58-59, 64-65, and 67-68 are not rendered obvious in view of Graves because Graves teaches ATM cells, 53 bytes in length, are reassembled into ATM Frame Relay packets segments and then converted into pure Frame Relay packets through SAR (Graves, col. 12, lines 57 – 67). The ATM cells, transmitted fixed sized cells at fixed time intervals which results in a synchronous system, are sent downstream in Frame structures to the ONU, are reassembled through SAR back into ATM format, which is inherently synchronous. As is well known, the ATM protocol transmits information in fixed-length 53 byte cells (48 bytes of payload and 5 bytes of overhead). The Internet protocol calls for data to be segmented into variable-length datagrams of up to 65,535 bytes. In order for an ATM cell to carry IP traffic within the HDT and the ONU for SAR over the PON, the IP datagrams must be broken into the intermediate stage of Frame Relay packets and then into ATM cells as 48 byte segments with a 5 byte header that must be added. The process of converting IP datagrams into ATM cells is time consuming for the HDT and the specialized hardware adds additional cost to the OLT and ONUs, even with the "hair pinning" taught in Graves. Graves teaches away from modifying the system of Graves to include the lengths of an IP datagram plus packet overhead.

In contrast to Graves and the use of SAR to carry IP datagrams in ATM cells, Applicants carry IP datagrams intact over the transport stage. In Applicants' invention, any IEEE 802.3 frame can be looked at over the PON link and an intact IP frame can be generally be "peeled out". However, in Graves' case, SAR must be applied in the appropriate stage before the IP frame is intact. In the event an IP datagram is fragmented

and encapsulated in Graves ATM cells, SAR must be used to obtain the original IP datagram whereas in Applicants' system and method, if the IP datagram is large enough that the IP datagram requires fragmentation, the IP datagram fragments are simply fragmented without encapsulation and may easily be placed back into the entire datagram. In this manner, carrying IP frames in the Graves invention is not cost effective nor time efficient as compared to Applicants' invention, as Graves cannot carry intact IP frames, but rather requires much more processing than Applicants' system and method.

Further, Applicants assert that the Graves invention was designed for datagrams smaller than an IP datagram. To support this, Applicants submit that formatting the length of the Frame Relay packets to include an IP datagram and overhead at the time the Graves patent was filed would have resulted in a discouraging performance and likely deterred any further pursuits due to lack of success. At the time the Graves patent was filed, the processing required first formatting an IP datagram in ATM cells (IP datagrams could give rise to a 20 byte overhead tax, leaving only 33 bytes of payload), converting the Frame Relay packets, filling the ATM cells following SAR processing and segmentation, which would cause congestion, traffic, and possible cell loss and cell threshold probability. In support, the most common way to release congestion at the time was to drop packets when there was insufficient buffer space, which may have caused a large IP packet to fail in the OLT preparation of the Frame Relay packet. The Graves invention was designed for POTS, ISDN, and DS-1. The Applicants assert that no suggestion or motivation to modify Graves existed at the time it was filed therefore existed. Further, the chance at success of including IP packets into the Graves system was not supported by an efficiency advantage nor economic advantage, and due to all of these limitations, the forgoing served to teach away from adapting IP packets into the system of Graves. Examiner has therefore not made a showing of the required prima *facie case* of obviousness.

<u>3.3 Claims 8, 28, 39, 60, and 69.</u>

Claims 8, 28, 39, 60, and 69 include limitations that recite using upstream and downstream variable length packets formatted according to IEEE 802.3 that include IP

datagrams. Applicants assert that the remarks provided directly above in 3.1 and 3.2 apply equally to these claims.

3.4 Claims 9, 29, and 70.

Claims 9, 29, and 70 include limitations that recite using a fragment buffer at the OLT for storing a first and a second packet transmitted from ONUs (upstream); and that the ONUs include fragment buffers for storing first and second packet that are to be transmitted from ONUs. Graves discloses a method and apparatus for synchronous ATM cells which are segmented and transported upstream and downstream between a HDT and ONU. The Office action states, "Graves does not teach that the OLT includes a fragment buffer for storing packets transmitted from ONUs (upstream); and that the ONUs include fragment buffers for storing packets that are to be transmitted from ONUs." The Office action goes on to conclude that "[h]owever, buffering data is used in almost all communications equipments" and "[i]t would have been obvious to one having ordinary skill in the art at the time the invention was made to add buffers to Grave's system in order to control data flow between ONUs and OLT." (Office action page 6, item 2.4).

Applicants assert that claims 9, 29, and 70 are not rendered obvious in view of Graves because Graves teaches ATM cells, 53 bytes in length, which must be reassembled into ATM Frame Relay packets segments and then converted into pure Frame Relay packets (SAR) (and *vice versa*) (Graves, col. 12, lines 57 – 67). Additionally, ATM is inherently synchronous and thus when segmented, is reassembled without the use of fragment buffers for storing packet fragments that have been transmitted upstream from the ONUs. Although the Frame Relay packets may have a variable length, the Frame Relay packets must be encapsulated within the ATM cells which are all uniform in length and in a synchronous stream, not variable-length and asynchronous as in IEEE 802.3.

Applicants assert that Protocol IEEE 802.3 is inherently asynchronous and thus start-of-packet-fragment buffers are very helpful by efficiently using time slots within a system according to IEEE 802.3 protocol. However, adding buffers to Graves' system would not allow control of asynchronous, unencapsulated frame fragmentation with end-of-packet-fragment and start-of-packet-fragment buffers because the Graves' system

must be synchronous and encapsulated, requiring SAR for encapsulation with every synchronous ATM cell. Applicants' fragmentation of unencapsualted IEEE 802.3 protocol frame payload with buffers is generally not needed, but can be used when the payload exceeds the size of the allocated upstream timeslots.

Conversely, the fragmentation of the Graves system is encapsulated fragmentation which requires the SAR process for converting ATM cells into Frame Relay packets. Adding such buffers to Graves would corrupt the ATM cells of Graves. Further, asynchronously dividing the Frame Relay packets would likely disrupt the ATM cells and thus segmentation, making ATM formatted packets unable to be processed by ATM protocol, therefore, Applicant asserts that Graves teaches away from using fragment buffers that store packet fragments which have been transmitted upstream.

3.5 Claims 10, 19, 30, 45, and 71

Claims 10, 19, 30, 45, and 71 recite a system and method in which the variable-length packets include the lengths of an IP datagram plus packet overhead. Graves discloses a method and apparatus for a synchronous ATM cells which are segmented and transported upstream and downstream between a HDT and ONU. The Office action states, "Graves does not disclose that the system comprises a fragment unit for splitting a variable-length upstream packet into first and second fragments; and adding an end-of-packet-fragment code to the first packet fragment and adding a start-of-packet-fragment code to the second packet fragment." The Office action goes on to conclude that "[h]owever, this feature is disclosed in Keenan's invention" and "[i]t would have been obvious to one having ordinary skill in the art at the time the invention was made to adapt to the packet fragment method disclosed by Keenan into Graves' system in order to utilize the bandwidth of the system for transmission." (Office action page 6, item 2.5)

Applicants assert that claims 9, 29, and 70 are not rendered obvious in view of Graves in light of Keenan because Graves teaches ATM cells, 53 bytes in length, are reassembled into ATM Frame Relay packet segments and then converted into pure Frame Relay packets (SAR) (and *vice versa*) (Graves, col. 12, lines 57 – 67). Keenan, on the other hand, discloses that "[d]ue to the asynchronous nature of the user data packets, a single Master Ethernet Packet must be capable of carrying the last segment of one

encapsulated user data packet and the first segment of the next encapsulated user data packet. In addition, the 're-assembly' section of the Ethernet [IEEE 802.3] SAR function needs a means of detecting the start, and end, octet of the encapsulated user data packet." (Keenan, col. 19, lines 32 – 38). ATM protocol, however, is inherently synchronous and thus, when segmented, ATM cells can be reassembled into Frame packets without the use of start-of-fragment-buffers or end-of-fragment-buffers, but ATM cells cannot be asynchronously separated by individual segments. Although the Frame Relay packets may have a variable length, the ATM cells are all uniform length and synchronous. Keenan discloses transport of variable size, asynchronous Ethernet (IEEE 802.3) frames but creates a synchronized scheme by fixing the IEEE 802.3 frame sizes. This allows the Keenan system to transport isochronous services over an Ethernet LAN, however, the Keenan system must encapsulate every User frame as part of the SAR (Keenan, col. 19, lines 32-38), which greatly adds to the complexity of the SAR process, as in Graves. Keenan uses fixed size Ethernet (IEEE 802.3) frames which cannot be too large in order to control latency of the voice payload. Keenan therefore always fragments the payload (very much like Graves). In contrast to both Keenan and Graves, Applicants use maximum size IEEE 802.3 in order to carry full IP frames without fragmentation.

Although both Keenan and Graves teach of encapsulating fixed sized frames, adaptation of the Keenan packet fragment method of adding end-of-packet-fragment code to the first packet fragment and adding a start-of-packet-fragment code to the second packet of IEEE 802.3 frames, even the size of the frames is fixed, could not be incorporated into Graves' system because the ATM cells in Graves must be synchronous and the Keenan codes are in a different format and layer than Graves Whereas Keenan encapsulates the asynchronous IEEE 802.3 frames into fixed sized frames, Applicants' system does not encapsulate asynchronous IEEE 802.3 frames. Further, because Keenan uses fixed size frames both upstream and downstream, the end-of-packet-fragment buffer and start-of-packet-fragment buffer are on different levels between Keenan and Applicants system and method. The Keenan start-of-fragment-packet buffer and end-of-packet buffer cannot be placed in the ATM cell overhead due to the resulting corruption or the different format of an Ethernet layer where it would need to be in order to function, but not in an ATM cell. The start-of-fragment-packet buffer and end-of-packet buffer

could be incorporated into the Graves ATM format, but in the payload of an ATM cell, but the desired function of the fragment buffers could not be realized by Graves because ATM cell payloads are not self extracting without even considering layers. Therefore, Graves, in light of Keenan, teaches away from using a start-of-packet-fragment buffer and an end-of-packet-fragment buffer because asynchronously dividing the encapsulated Frame Relay packets and ATM cells would likely disrupt the required synchronicity, synchronous stream, as well as segmentation and reassembly (SAR).

In contrast, Applicants system and method using Protocol IEEE 802.3 (Ethernet) inherently asynchronous and unencapsulated variable sized frames where the fragment buffers in the correct layer are very helpful in more efficiently using time slots with variable sized frames within a system according to IEEE 802.3 protocol. Thus, Applicant asserts that Keenan cannot be adapted into Graves' system end-of-packet-fragment buffers and start-of-packet-fragment buffers due to ATM system protocol differences and resulting corruption such that other ATM systems would be unable to process packets from Graves.

3.6 Claim 32

Claim 32 includes limitations that recite using upstream and downstream variable length packets transmitted from OLT to ONUs and from ONUs to OLT over a PON using time division multiplexing and fragment buffers included at the OLT and ONUs. Applicants assert that the remarks provided directly above in 3.4 and 3.5 apply equally to these claims.

3.7 Claim 47

Claim 47 includes limitations that recite using upstream and downstream variable length packets transmitted from OLT to ONUs and from ONUs to OLT over a PON using time division multiplexing (TDM) and fragment buffers included at the OLT and ONUs. Applicants assert that the remarks provided directly above in 3.4 and 3.5 apply equally to these claims.

3.8 Claim 50

Claim 50 is canceled and is therefore not addressed herein.

3.9 Claim 51

Claim 51 is canceled and is therefore not addressed herein.

3.10 Claim 53

Claim 53 includes limitations that recite a means to format data into upstream and downstream variable length packets transmitted from OLT to ONUs and from ONUs to OLT over a PON using TDM and fragment buffers included at the OLT and ONUs and splitting variable length packets into start-of-packet-fragment and end-of-packet-fragment buffers. Applicants assert that the remarks provided directly above in 3.4 and 3.5 apply equally to these claims.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached pages are captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE." Applicants respectfully request reconsideration of the claims in view of the amendments and remarks made herein. A notice of allowance is, again, earnestly solicited. Should the examiner be interested, Applicants respectfully requests a telephone interview to discuss whatever additional questions or comments the examiner may have.

Respectfully submitted,

Marc E. Hankin

Marc E. Hankin
Reg. No. 38,908
Date: May 6, 2003

APTI\1013638\38973.1

1. (amended) A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT); and

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs over said passive optical network and upstream data is transmitted from said ONUs to said OLT over said passive optical network, wherein said upstream data is formatted according to IEEE 802.3;

said OLT transmitting downstream data over said passive optical network in variable-length downstream packets;

said ONUs transmitting upstream data over said passive optical network within ONU-specific time slots utilizing time division multiplexing, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets and .

2. The system of claim 1 wherein said variable-length downstream packets are formatted according to IEEE 802.3..

3. The system of claim 1 wherein said variable-length downstream packets include Internet protocol (IP) datagrams.

4. (amended) The system of claim 3 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

5. (canceled) ~~The system of claim 1 wherein said variable-length upstream packets are formatted according to IEEE 802.3.~~

6. The system of claim 1 wherein said variable-length upstream packets include Internet protocol (IP) datagrams.

7. (amended) The system of claim 6 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

8. The system of claim 1 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream data and said upstream data include Internet protocol (IP) datagrams.

9. The system of claim 1 wherein:

said OLT includes a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs; and

said ONUs include fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs.

10. The system of claim 9 wherein said ONUs include fragment logic for:

splitting a variable-length upstream packet into first and second packet fragments; and

adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment.

11. The system of claim 10 wherein said OLT includes fragment logic for:
identifying said end-of-packet-fragment code of said first packet fragment;
buffering said first packet fragment in said OLT fragment buffer;
identifying said start-of-packet-fragment code of said first packet fragment;
reconstructing said variable-length upstream packet from said first and second packet fragments.

12. (twice amended) A method for exchanging information between an optical line terminal (OLT) and multiple optical network units (ONUs) in a point-to-multipoint passive optical network comprising:
transmitting downstream data from said OLT to said ONUs in variable-length downstream packets;
transmitting upstream data from said ONUs to said OLT in ONU-specific time slots utilizing time division multiplexing to avoid transmission collisions, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets formatted according to IEEE 802.3.

13.The method of claim 12 wherein said variable-length downstream and upstream packets are formatted in accordance with the IEEE 802.3 protocol.

14. (amended) The method of claim 12 wherein said variable-length downstream and upstream packets include packet overhead and a payload, and wherein the length of each of said variable-length packets includes the length of an Internet protocol (IP) datagram that is included in the payload of each of said variable-length packets plus the packet overhead.

15. (canceled)

16. (canceled)

17. (canceled) ~~The method of claim 12 wherein said step of transmitting downstream data includes transmitting downstream synchronization markers at constant time intervals.~~

18. (canceled)

19.The method of claim 12 further including the steps of:
splitting a variable-length upstream packet into a first packet fragment and a second packet fragment;
adding an end-of-packet-fragment code to the end of said first packet fragment; and
adding a start-of-packet-fragment code to the start of said second packet fragment.

20. The method of claim 19 further including steps of:

transmitting said first packet fragment upstream in a first ONU-specific time slot;

buffering said second packet fragment for transmission in a second ONU- specific time slot that is different from said first ONU-specific time slot;

buffering said first packet fragment after said first packet fragment is received at said OLT; and

reconstructing said variable-length upstream packet, at said OLT, from said first packet fragment and said second packet fragment.

21. (twice amended) A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT); and

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs and upstream data is transmitted from said ONUs to said OLT;

said OLT including means for formatting downstream datagrams into variable-length downstream packets;

each of said ONUs including:

means for formatting upstream datagrams into variable-length upstream packets according to IEEE 802.3;

and means for timing the transmission of said variable- length upstream packets to coincide with ONU-specific time slots in order to avoid collisions with upstream packets from other ONUs, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets.

22. The system of claim 21 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

23. The system of claim 21 wherein said downstream datagrams are Internet protocol (IP) datagrams.

24. (amended) The system of claim 23 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

25. (canceled) ~~The system of claim 1 wherein said variable-length upstream packets are formatted according to IEEE 802.3~~.

26. The system of claim 21 wherein said upstream datagrams are Internet protocol (IP) datagrams.

27. (amended) The system of claim 26 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

28.The system of claim 21 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream datagrams and said upstream datagrams are Internet protocol (IP) datagrams.

29. The system of claim 21 wherein:

said OLT includes a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs;

and said ONUs include fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs.

30. The system of claim 29 wherein said ONUs include fragment logic for:

splitting a variable-length upstream packet into first and second packet fragments; and

adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment.

31. The system of claim 30 wherein said OLT includes fragment logic for:

identifying said end-of-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment; and

reconstructing said variable-length upstream packet from said first and second packet fragments.

32. A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT); and

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs over said passive optical network and upstream data is transmitted from said ONUs to said OLT over said passive optical network;

said OLT transmitting downstream data over said passive optical network in variable-length downstream packets;

said ONUs transmitting upstream data over said passive optical network within ONU-specific time slots utilizing time division multiplexing, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets;

said OLT including a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs; and

said ONUs including:

fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs; and

fragment logic for splitting a variable-length upstream packet into first and second packet fragments, adding an end-of-packet-fragment code to said first packet fragment, and adding a start-of-packet-fragment code to said second packet fragment.

33. The system of claim 32 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

34. The system of claim 32 wherein said variable-length downstream packets include Internet protocol (IP) datagrams.

35. The system of claim 34 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

36. The system of claim 32 wherein said variable-length upstream packets are formatted according to IEEE 802.3.

37. The system of claim 32 wherein said variable-length upstream packets include Internet protocol (IP) datagrams.

38. The system of claim 37 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

39. The system of claim 32 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream data and said upstream data include Internet protocol (IP) datagrams.

40. The system of claim 32 wherein said OLT includes fragment logic for:

identifying said end-of-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment; and,

reconstructing said variable-length upstream packet from said first and second packet fragments.

41. (amended) A method for exchanging information between an optical line terminal (OLT) and multiple optical network units (ONUs) in a point-to-multipoint passive optical network comprising:

transmitting downstream data from said OLT to said ONUs in variable-length downstream packets;

transmitting downstream synchronization markers at constant time intervals;

and transmitting upstream data from said ONUs to said OLT in ONU-specific time slots utilizing time division multiplexing to avoid transmission collisions, wherein said ONU-specific time slots are filled with variable-length upstream packets <u>formatted according to IEEE 802.3</u>.

42. The method of claim 41 wherein said variable-length downstream and upstream packets are formatted in accordance with the IEEE 802.3 protocol.

43. The method of claim 41 wherein said variable-length downstream and upstream packets include packet overhead and a payload, and wherein the length of each of said variable-length packets includes the length of an Internet protocol (IP) datagram that is included in the payload of each of said variable-length packets plus the packet overhead.

44. The method of claim 41 wherein said ONU-specific time slots are filled with multiple variable-length packets.

45. The method of claim 41 further including the steps of:

splitting a variable-length upstream packet into a first packet fragment and a second packet fragment;

adding an end-of-packet-fragment code to the end of said first packet fragment; and

adding a start-of-packet-fragment code to the start of said second packet fragment.

46. The method of claim 45 further including steps of:

transmitting said first packet fragment upstream in a first ONU-specific to time slot;

buffering said second packet fragment for transmission in a second ONU-specific time slot that is different from said first ONU-specific time slot;

buffering said first packet fragment after said first packet fragment is received at said OLT; and

reconstructing said variable-length upstream packet, at said OLT, from said first packet fragment and said second packet fragment.

47. A method for exchanging information between an optical line terminal (OLT) and multiple optical network units (ONUs) in a point-to-multipoint passive optical network comprising:

transmitting downstream data from said OLT to said ONUs in variable-length downstream packets;

transmitting upstream data from said ONUs to said OLT in ONU-specific time slots utilizing time division multiplexing to avoid transmission collisions, wherein said ONU-specific time slots are filled with variable-length upstream packets;

splitting a variable-length upstream packet into a first packet fragment and a second packet fragment;

adding an end-of-packet-fragment code to the end of said first packet fragment; and

adding a start-of-packet-fragment code to the start of said second packet fragment.

48. The method of claim 47 wherein said variable-length downstream and upstream packets are formatted in accordance with the IEEE 802.3 protocol.

49. The method of claim 47 wherein said variable-length downstream and upstream packets include packet overhead and a payload, and wherein the length of each of said variable-length packets includes the length of an Internet protocol (IP) datagram that is included in the payload of each of said variable-length packets plus the packet overhead.

50. (canceled) ~~The method of claim 47 wherein said step of transmitting downstream data includes transmitting downstream synchronization markers at constant time intervals.~~

51. (canceled) ~~The method of claim 47 wherein said ONU-specific time slots are filled with multiple variable length packets.~~

52. The method of claim 47 further including steps of:
transmitting said first packet fragment upstream in a first ONU-specific time slot;
buffering said second packet fragment for transmission in a second ONU specific time slot that is different from said first ONU-specific time slot;
buffering said first packet fragment after said first packet fragment is received at said OLT; and
reconstructing said variable-length upstream packet, at said OLT, from said first packet fragment and said second packet fragment.

53. A point-to-multipoint optical communications system comprising:
an optical line terminal (OLT); and
a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs and upstream data is transmitted from said ONUs to said OLT;
said OLT including means for formatting downstream datagrams into variable-length downstream packets and a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs;
each of said ONUs including:
means for formatting upstream datagrams into variable-length upstream packets;
means for timing the transmission of said variable- length upstream packets to coincide with ONU-specific time slots in order to avoid collisions with upstream packets from other ONUs;
fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs; and
fragment logic for:
splitting a variable-length upstream packet into first and second packet fragments; and
adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment.

54. The system of claim 53 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

55. The system of claim 53 wherein said downstream datagrams are Internet protocol (IP) datagrams.

56. The system of claim 55 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

57. The system of claim 53 wherein said variable-length upstream packets are formatted according to IEEE 802.3.

58. The system of claim 53 wherein said upstream datagrams are Internet protocol (IP) datagrams.

59. The system of claim 58 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

60. The system of claim 53 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream datagrams and said upstream datagrams are Internet protocol (IP) datagrams.

61. The system of claim 53 wherein said OLT includes fragment logic for:

identifying said end-bf-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment; and

reconstructing said variable-length upstream packet from said first and second packet fragments.

62. (amended) A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT);

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs over said passive optical network and upstream data is transmitted from said ONUs to said OLT over said passive optical network;

said OLT transmitting downstream data over said passive optical network in variable-length downstream packets and downstream synchronization markers at constant time intervals;

said ONUs transmitting upstream data over said passive optical network within ONU-specific time slots utilizing time division multiplexing, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets <u>formatted according to IEEE 802.3</u>.

63. The system of claim 62 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

64. The system of claim 62 wherein said variable-length downstream packets include Internet protocol (IP) datagrams.

65. The system of claim 64 wherein the lengths of said variable length downstream packets includes the lengths of said IP datagrams plus packet overhead.

66. (canceled) ~~The system of claim 1 wherein said variable-length upstream packets are formatted according to IEEE 802.3.~~

67. The system of claim 62 wherein said variable-length upstream packets include Internet protocol (IP) datagrams.

68. The system of claim 67 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

69. The system of claim 62 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream data and said upstream data include Internet protocol (IP) datagrams.

70. The system of claim 62 wherein:

said OLT includes a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs; and

said ONUs include fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs.

71. The system of claim 70 wherein said ONUs include fragment logic for:

splitting a variable-length upstream packet into first and second packet fragments; and

adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment.

72. The system of claim 71 wherein said OLT includes fragment logic for:

identifying said end-of-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment; and

reconstructing said variable-length upstream packet from said first and second packet fragments.

<u>73. (new) A point-to-multipoint optical communications system comprising:</u>

<u>an optical line terminal (OLT); and</u>

<u>a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs over said passive optical network and upstream data is transmitted from said ONUs to said OLT over said passive optical network;</u>

<u>said OLT transmitting downstream data over said passive optical network in variable-length downstream packets;</u>

<u>said ONUs transmitting upstream data over said passive optical network within ONU-specific time slots utilizing time division multiplexing, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets;</u>

X <u>said OLT includes:</u>

<u>a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs; and</u>

<u>fragment logic for:</u>

identifying said end-of-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said first packet fragment;

reconstructing said variable-length upstream packet from said first and second packet fragments;

said ONUs include:

fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs; and

fragment logic for:

splitting a variable-length upstream packet into first and second packet fragments; and

adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment.

74. (new) The system of claim 73 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

75. (new) The system of claim 73 wherein said variable-length downstream packets include Internet protocol (IP) datagrams.

76. (new) The system of claim 75 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

77. (new) The system of claim 73 wherein said variable-length upstream packets include Internet protocol (IP) datagrams.

78. (new) The system of claim 77 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

79. (new) The system of claim 73 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream data and said upstream data include Internet protocol (IP) datagrams.

80. (new) A method for exchanging information between an optical line terminal (OLT) and multiple optical network units (ONUs) in a point-to-multipoint passive optical network comprising:

transmitting downstream data from said OLT to said ONUs in variable-length downstream packets;

transmitting upstream data from said ONUs to said OLT in ONU-specific time slots utilizing time division multiplexing to avoid transmission collisions, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets;

splitting a variable-length upstream packet into a first packet fragment and a second packet fragment;

adding an end-of-packet-fragment code to the end of said first packet fragment;

adding a start-of-packet-fragment code to the start of said second packet fragment;

transmitting said first packet fragment upstream in a first ONU-specific time slot;

buffering said second packet fragment for transmission in a second ONU- specific time slot that is different from said first ONU-specific time slot;

buffering said first packet fragment after said first packet fragment is received at said OLT; and

reconstructing said variable-length upstream packet, at said OLT, from said first packet fragment and said second packet fragment.

81. (new) The method of claim 80 wherein said variable-length downstream and upstream packets are formatted in accordance with the IEEE 802.3 protocol.

82. (new) The method of claim 80 wherein said variable-length downstream and upstream packets include packet overhead and a payload, and wherein the length of each of said variable-length packets includes the length of an Internet protocol (IP) datagram that is included in the payload of each of said variable-length packets plus the packet overhead.

83. (new) A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT); and

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs and upstream data is transmitted from said ONUs to said OLT;

said OLT including means for formatting downstream datagrams into variable-length downstream packets;

each of said ONUs including:

means for formatting upstream datagrams into variable-length upstream packets; and

means for timing the transmission of said variable- length upstream packets to coincide with ONU-specific time slots in order to avoid collisions with upstream packets from other ONUs, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets;

said OLT includes:

a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs;

fragment logic for:

identifying said end-of-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment; and

reconstructing said variable-length upstream packet from said first and second packet fragments;

said ONUs include:

fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs;

fragment logic for:

splitting a variable-length upstream packet into first and second packet fragments; and

adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment.

84. (new) The system of claim 83 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

85. (new) The system of claim 83 wherein said downstream datagrams are Internet protocol (IP) datagrams.

86. (new) The system of claim 85 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

87. (new) The system of claim 83 wherein said upstream datagrams are Internet protocol (IP) datagrams.

88. (new) The system of claim 87 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

89. (new) The system of claim 83 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream datagrams and said upstream datagrams are Internet protocol (IP) datagrams.

90. (new) A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT); and

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs over said passive optical network and upstream data is transmitted from said ONUs to said OLT over said passive optical network;

said OLT transmitting downstream data over said passive optical network in variable-length downstream packets;

said ONUs transmitting upstream data over said passive optical network within ONU-specific time slots utilizing time division multiplexing, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets;

said OLT including a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs;

said ONUs including:

fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs;

fragment logic for splitting a variable-length upstream packet into first and second packet fragments, adding an end-of-packet-fragment code to said first packet fragment, and adding a start-of-packet-fragment code to said second packet fragment;

said OLT includes fragment logic for:

identifying said end-of-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment; and

reconstructing said variable-length upstream packet from said first and second packet fragments.

91. (new) The system of claim 90 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

92. (new) The system of claim 90 wherein said variable-length downstream packets include Internet protocol (IP) datagrams.

93. (new) The system of claim 92 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

94. (new) The system of claim 90 wherein said variable-length upstream packets are formatted according to IEEE 802.3.

95. (new) The system of claim 90 wherein said variable-length upstream packets include Internet protocol (IP) datagrams.

96. (new) The system of claim 95 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

97. (new) The system of claim 90 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream data and said upstream data include Internet protocol (IP) datagrams.

98. (new) A method for exchanging information between an optical line terminal (OLT) and multiple optical network units (ONUs) in a point-to-multipoint passive optical network comprising:

transmitting downstream data from said OLT to said ONUs in variable-length downstream packets;

transmitting downstream synchronization markers at constant time intervals;

transmitting upstream data from said ONUs to said OLT in ONU-specific time slots utilizing time division multiplexing to avoid transmission collisions, wherein said ONU-specific time slots are filled with variable-length upstream packets;

splitting a variable-length upstream packet into a first packet fragment and a second packet fragment;

adding an end-of-packet-fragment code to the end of said first packet fragment;

adding a start-of-packet-fragment code to the start of said second packet fragment;

transmitting said first packet fragment upstream in a first ONU-specific to time slot;

buffering said second packet fragment for transmission in a second ONU-specific time slot that is different from said first ONU-specific time slot;

buffering said first packet fragment after said first packet fragment is received at said OLT; and

reconstructing said variable-length upstream packet, at said OLT, from said first packet fragment and said second packet fragment.

99. (new) The method of claim 98 wherein said variable-length downstream and upstream packets are formatted in accordance with the IEEE 802.3 protocol.

100. (new) The method of claim 98 wherein said variable-length downstream and upstream packets include packet overhead and a payload, and wherein the length of each of said variable-length packets includes the length of an Internet protocol (IP) datagram that is included in the payload of each of said variable-length packets plus the packet overhead.

101. (new) The method of claim 98 wherein said ONU-specific time slots are filled with multiple variable-length packets according to IEEE 802.3 format.

102. (new) A method for exchanging information between an optical line terminal (OLT) and multiple optical network units (ONUs) in a point-to-multipoint passive optical network comprising:

transmitting downstream data from said OLT to said ONUs in variable-length downstream packets;

transmitting upstream data from said ONUs to said OLT in ONU-specific time slots utilizing time division multiplexing to avoid transmission collisions, wherein said ONU-specific time slots are filled with variable-length upstream packets;

splitting a variable-length upstream packet into a first packet fragment and a second packet fragment;

adding an end-of-packet-fragment code to the end of said first packet fragment;

adding a start-of-packet-fragment code to the start of said second packet fragment;

transmitting said first packet fragment upstream in a first ONU-specific time slot;

buffering said second packet fragment for transmission in a second ONU specific time slot that is different from said first ONU-specific time slot;

buffering said first packet fragment after said first packet fragment is received at said OLT; and

reconstructing said variable-length upstream packet, at said OLT, from said first packet fragment and said second packet fragment.

103. (new) The method of claim 102 wherein said variable-length downstream and upstream packets are formatted in accordance with the IEEE 802.3 protocol.

104. (new) The method of claim 102 wherein said variable-length downstream and upstream packets include packet overhead and a payload, and wherein the length of each of said variable-length packets includes the length of an Internet protocol (IP) datagram that is included in the payload of each of said variable-length packets plus the packet overhead.

105. (new) A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT); and

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs and upstream data is transmitted from said ONUs to said OLT;

said OLT including means for formatting downstream datagrams into variable-length downstream packets and a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs;

each of said ONUs including:

means for formatting upstream datagrams into variable-length upstream packets;

means for timing the transmission of said variable-length upstream packets to coincide with ONU-specific time slots in order to avoid collisions with upstream packets from other ONUs;

fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs; and

fragment logic for:

splitting a variable-length upstream packet into first and second packet fragments; and

adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment;

said OLT including fragment logic for:

identifying said end-of-packet-fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment; and

reconstructing said variable-length upstream packet from said first and second packet fragments.

106. (new) The system of claim 105 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

107. (new) The system of claim 105 wherein said downstream datagrams are Internet protocol (IP) datagrams.

108. (new) The system of claim 107 wherein the lengths of said variable-length downstream packets include the lengths of said IP datagrams plus packet overhead.

109. (new) The system of claim 105 wherein said variable-length upstream packets are formatted according to IEEE 802.3.

110. (new) The system of claim 105 wherein said upstream datagrams are Internet protocol (IP) datagrams.

111. (new) The system of claim 110 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

112. (new) The system of claim 105 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream datagrams and said upstream datagrams are Internet protocol (IP) datagrams.

113. (new) A point-to-multipoint optical communications system comprising:

an optical line terminal (OLT); and

a plurality of optical network units (ONUs) connected to said OLT by a passive optical network in which downstream data is transmitted from said OLT to said ONUs over said passive optical network and upstream data is transmitted from said ONUs to said OLT over said passive optical network;

said OLT transmitting downstream data over said passive optical network in variable-length downstream packets and downstream synchronization markers at constant time intervals;

said ONUs transmitting upstream data over said passive optical network within ONU-specific time slots utilizing time division multiplexing, wherein said ONU-specific time slots are filled with multiple variable-length upstream packets.

said OLT includes:

a fragment buffer for storing packet fragments that have been transmitted upstream from said ONUs;

fragment logic for:

identifying said end-of-packet fragment code of said first packet fragment;

buffering said first packet fragment in said OLT fragment buffer;

identifying said start-of-packet-fragment code of said second packet fragment;

reconstructing said variable-length upstream packet from said first and second packet fragments;

said ONUs include:

fragment buffers for storing packet fragments that are to be transmitted upstream from said ONUs;

fragment logic for:

splitting a variable-length upstream packet into first and second packet fragments; and

adding an end-of-packet-fragment code to said first packet fragment and adding a start-of-packet-fragment code to said second packet fragment.

114. (new) The system of claim 113 wherein said variable-length downstream packets are formatted according to IEEE 802.3.

115. (new) The system of claim 113 wherein said variable-length downstream packets include Internet protocol (IP) datagrams.

116. (new) The system of claim 115 wherein the lengths of said variable length downstream packets includes the lengths of said IP datagrams plus packet overhead.

117. (new) The system of claim 113 wherein said variable-length upstream packets include Internet protocol (IP) datagrams.

118. (new) The system of claim 117 wherein the lengths of said variable-length upstream packets include the lengths of said IP datagrams plus packet overhead.

119. (new) The system of claim 113 wherein:

said variable-length downstream packets and said variable-length upstream packets are formatted according to IEEE 802.3; and

said downstream data and said upstream data include Internet protocol (IP) datagrams.